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Surgical procedure and retrospective comparative series of Microport's AnteriorPath® vs. AMIS® in total hip arthroplasty. Preliminary findings from a single institution

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ABSTRACT

Objective: In recent years, the paradigm of surgical approaches for total hip arthroplasty (THA) has evolved, with portal-assisted techniques emerging as a promising avenue for increasing precision and minimizing invasiveness. The purpose of this study was to compare early experience with the Microport anterior percutaneously (MAP) assisted THA system, with the established AMIS direct anterior approach (DAA).

Material and Methods: A retrospective chart analysis was performed on 200 consecutive patients who underwent DAA or MAP at our institution in 2022. The research was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and was approved by the institutional review board of the University Duisburg-Essen (23-11274-BO).

Results: Two hundred patients were enrolled (100 DAA and 100 MAP; time to follow-up 1.7 years ±88 days). The mean operative time was 81 minutes (MAP) and 67 minutes (DAA, p>0.05). The mean cup tilt angle was 39° (MAP) and 40° (DAA; p>0.05). The mean cup anteversion angle was 13° (MAP) and 16° (DAA; p>0.05). The mean postoperative hemoglobin (Hb) decrease was 2.6 mg/dL ±0.9 mg/dL (MAP) and 2.5 mg/dL ±0.9 mg/dL (DAA; p>0.05). No major complications were documented in any of the 200 cases during the observation period. Additional screw fixation was performed in 7 cases and hybrid stem cementation was performed in 3 cases due to lack of rotational stability. All 10 cases were in patients with DAA. In only one of the 200 cases, two units of RBC were transfused postoperatively in a DAA case after a postoperative decrease of 5.7 mg/dL Hb.

Conclusion: Anterior Path® has been demonstrated to provide reliable results, despite the presence of a steep learning curve. The employment of a working cannula has been shown to enhance the surgeon's perspective during the preparation of the acetabulum. In relation to skin incision, the bikini line incision, which is regarded as advantageous due to its alignment with the cleavage lines, has been identified as a notable benefit that is acknowledged by the patient.

Keywords: AMIS, arthroplasty, bikini incision, DAA, Microport, Medacta, total hip arthroplasty

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INTRODUCTION

Traditional total hip arthroplasty (THA) techniques have shown remarkable success rates in relieving pain, improving function, and enhancing patients' quality of life. However, the invasiveness of conventional procedures can lead to prolonged recovery periods and increased morbidity (1).

In recent years, a growing emphasis on minimally invasive surgical techniques has emerged within the orthopedic community (2). These approaches aim to achieve the same therapeutic goals as traditional THA while minimizing surgical trauma, reducing postoperative pain, shortening hospital stays, and facilitating faster rehabilitation. Consequently, surgeons have been exploring innovative techniques to refine and advance the field of minimally invasive total hip arthroplasty (MI-THA) (2-5).

MI-THA using the direct anterior approach (DAA) has been shown to have advantages over other approaches, such as the posterolateral approach (PLA) and the SuperPath® (SP) approach (6). Studies have shown that DAA results in less intraoperative bleeding, less muscle damage, and a lower incidence of hip dislocation (7). In addition, DAA has been shown to be an appropriate approach for primary THA in patients with complex acetabular deformities, such as coxa profunda and protrusio acetabuli (8). Recent evidence suggests that DAA is also effective in obese patients, with relatively low complication rates and satisfactory clinical outcomes (9). In addition, DAA has been shown to have comparable radiographic parameters to other minimally invasive approaches, such as the SP approach (10). Overall, the DAA is a safe and effective approach to THA, with advantages in terms of reduced intraoperative bleeding, muscle damage, and postoperative recovery, as well as comparable radiographic parameters and clinical outcomes to other approaches. The MAP technique used in this study involves smaller incisions, less soft tissue disruption, and a modified surgical approach. In addition to the well-known percutaneously assisted Microport approaches already described in the literature, MAP is a percutaneously assisted system for MI-THA that allows skin incision along the cleavage lines (11-15).

Through this innovative approach, we aim to minimize surgical trauma, reduce blood loss, and expedite the recovery process without compromising the accuracy and longevity of the implant. The authors are not aware of any studies comparing conventional DAA and Microport's AnteriorPath® (MAP; AnteriorPath, MicroPort Orthopedics Inc., Arlington, TN, USA) for MI-THA. In this study, we provide an overview of the surgical technique, patient selection criteria, and a comprehensive analysis of early results observed in a cohort of patients who underwent the recently applied MAP procedure compared with those of patients who underwent a well-established DAA at our institution.

MATERIAL and METHODS

This study presents the early results and radiographic outcomes of the newly applied MAP procedure, which combines the principles of minimally invasive surgery with the technical demands of THA. Patients enrolled in this study presented with degenerative osteoarthritis for elective primary THA after failure of non-operative management. Patients were divided into two groups (MAP and DAA). The evaluation included cup orientation, operative time, blood loss, complications that may have occurred during the follow-up period, length of hospital stay, and opiate use. Cup position was measured on scaled standard radiographs by a board-certified surgeon. Approved measurement techniques were used to measure anteversion and abduction of the cup (16).

Statistical Analysis

Data collection was performed by a board-certified surgeon. Statistical analysis was performed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Evaluation was carried out with descriptive statistics. For numerical data, means, standard deviations, medians, and quartiles were calculated depending on the distribution. A p-value <0.05 was deemed significant. The cumulative average of surgery time was used to evaluate the learning curve. The Mann-Kendall trend test was used because it does not depend on the normal distribution of the data and is suitable for time series data. The research was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the institutional review board of the University Duisburg-Essen (23-11274-BO).

Preoperative Planning/Patient Positioning

Preoperative digital templating was performed from a standardized anteroposterior radiograph of the pelvis using a radio-opaque size marker. Offset and the presence of any leg length discrepancy were accounted for in the placement of the templated components. The distance from the tip of the greater trochanter to the shoulder of the femoral component was measured as a reference for planned intraoperative placement. The patient was positioned in supine position on the operating table. The skin incision line is marked before disinfecting the surgical area between the costal arch and the median plane of the abdomen, including the entire ipsilateral leg (Figure 1). A straight line is drawn between the proximal patellar pole and the anterior superior iliac spine. Another line is drawn at a 90° angle to the previously drawn line from the anterior superior iliac spine to the dorsolateral side. A third line is drawn from the tip of the greater trochanter at a 90° angle to the first line drawn. This creates a square with the inguinal crease, which serves as another landmark for placement of the skin incision (Figure 1).

Surgical Procedure

All surgeries were performed by two experienced hip surgeons (HH performed MAP; UH performed DAA). A digitalized planning tool (mediCad®, HECTEC™ GmbH, Landshut, Germany) was used for preoperative planning. After the skin incision is made in the bikini line (Figure 1), the subcutaneous preparation is continued to the thigh fascia (Figure 2). In some cases, branches of the lateral femoral cutaneous nerve may be found in the medial area of the skin incision and should be protected. Laterally, the tensor fasciae latae muscle shimmers through the fascia, with a fat-filled interval visible medially. The fascia is split longitudinally at the belly of the tensor fasciae latae muscle, and the muscle is bypassed medially; the muscle interval is bluntly dissected deeply with the surgeon's finger. A blunt Hohmann retractor can now be placed laterally onto the proximal femur (Figure 2c). The sartorius muscle is medialized with a round hook to ligate or coagulate the palpable perforator vessels in the muscle interval, to achieve cranial dissection. Once the surgeon's finger can pass ventrally around the neck of the femur, a MIS Hohman hook can be placed cranially on the neck of the femur (Figure 2d). Another MIS hook is placed caudally on the femoral neck (Figure 2b) after adhesions of the ventral capsule have been loosened with the Cobb raspatory, and a fourth MIS hook is placed on the ventral acetabulum (Figure 2a). The hip joint capsule is now visibly stretched (Figure 2b). After the ventral capsule has been removed and the hooks on the femoral neck have been moved intracapsularly, the double femoral neck osteotomy is performed. A medial osteotomy is performed on the anatomic collum, and a second wedge-shaped osteotomy is performed on the surgical collum. After removal of the bone wedge, the femoral head can now be removed from the acetabulum (Figure 3). It is helpful to screw the corkscrew in at the transition to the cartilaginous surface of the femoral head or within the cartilaginous surface of the femoral head (Figure 3A). This may prevent the corkscrew from being torn out of the cancellous femoral bone when removing the femoral head. The percutaneously assisted targeting instrument set is inserted, and the working cannula is inserted through a stab incision (Figure 4). The first reamer may be inserted through the skin incision for medial opening of the acetabulum, if desired. All following reamers are then inserted into the acetabulum through the bikini incision and reamed through the percutaneous working sheath until the desired size is reached. The original cup is also delivered through the working cannula (Figure 4). To prepare the femoral shaft, a slit is made in the peritrochanteric musculature dorsolateral to the tip of the greater trochanter using a monopolar electrocautery blade to position the femoral elevator at this point. The patient's leg is then lowered, adducted, and externally rotated to achieve extension of the hip (Figure 5). In conjunction with adduction of the operated leg and external rotation, and elevation of the proximal femur by the assistant using the Femoral elevator hook, stem preparation can now be performed as usual.

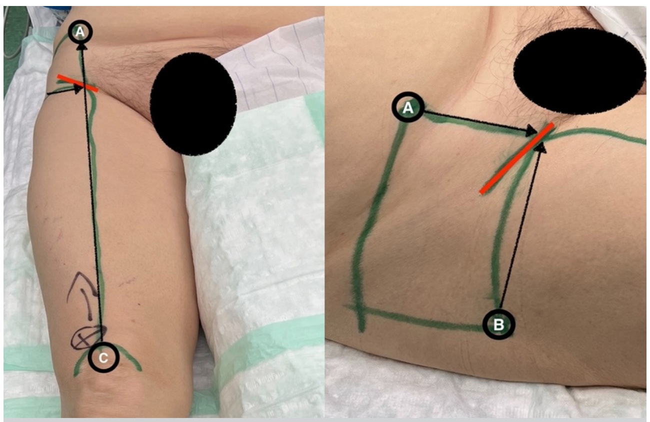

Figure 1. Sketch of landmarks for bikini incision (red line). A: Anterior superior iliac spine. B: Tip of the greater trochanter. C: Proximal patellar pole.

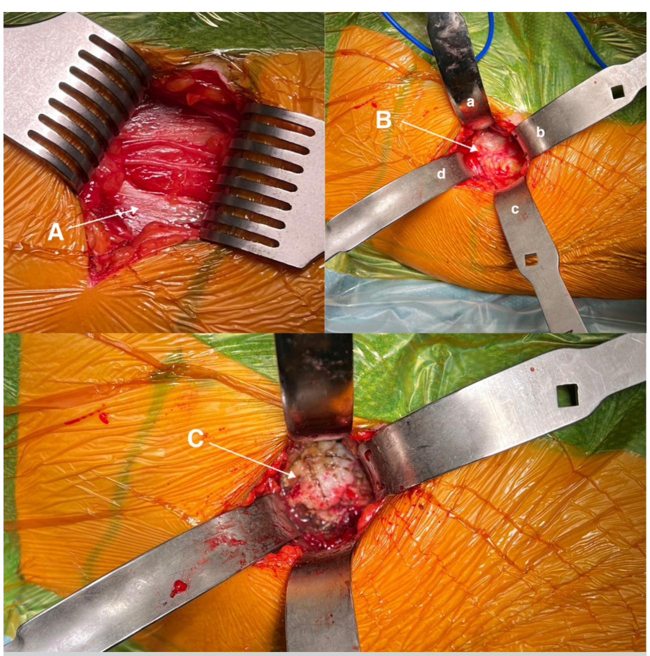

Figure 2. Illustration of the surgical situs after subcutaneous preparation with exposure of the fascia lata (A), after opening the muscle interval and positioning the 4 hooks on the anterior acetabular rim (a), on the caudal femoral neck (b), laterally on the greater trochanter (c), and on the cranial femoral neck before (B), and after (C) removal of the joint capsule.

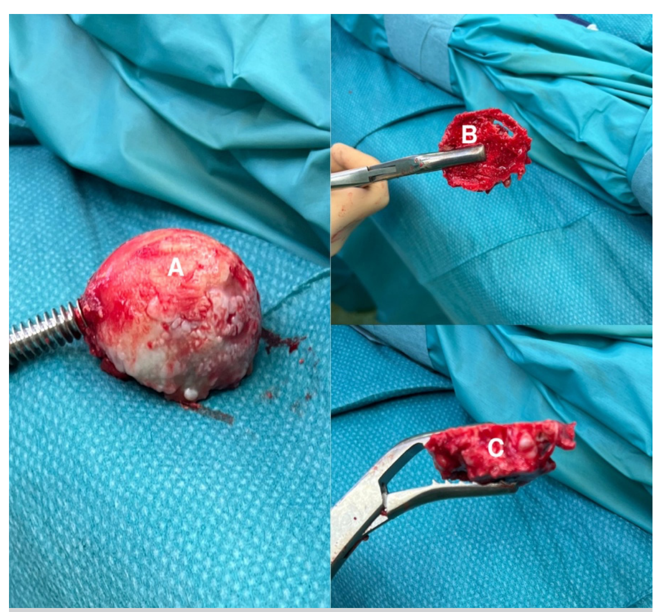

Figure 3. View of the femoral head (A) and femoral neck disc removal from an axial view (B) and lateral view (C) after double osteotomy.

RESULTS

Two hundred patients were enrolled: 100 patients received 100 patients received a DAA and 100 received an MAP. The mean age in both groups was 68 years (±11 y.). 59% (MAP) and 72% (DAA) of the patients were women. The mean body mass index (BMI) was similar in both groups, with a mean BMI of 26.96 kg/m^2 in the (MAP) group and 27.64 kg/m^2 in the (DAA) group. The average time to follow-up in both groups was 1.7 years (±88 days). The mean operative time was 81 minutes (MAP) and 67 minutes (DAA), p>0.05. The average cup tilt angle was 39° (MAP) and 40° (DAA; p>0.05). The average cup anteversion angle was 13° (MAP) and 16° (DAA), p>0.05. The mean postoperative hemoglobin (Hb) decrease was 2.6 mg/dL ±0.9 mg/dL (MAP) and 2.5 mg/dL ±0.9 mg/dL (DAA, p>0.05). Additional screw fixation of the cup was performed in 7 cases and cementation of the stem was performed in 3 cases due to lack of intraoperative rotational stability. All 10 cases involved patients in the DAA group. In only one of 200 cases, two units of RBCs (approximately 600 mL) were transfused postoperatively after the patient lost 5.7 g/dL Hb intraoperatively. This transfusion case also involved a patient in the DAA group. Our results showed that there is a steep learning curve within the first MAP. Analysis of the learning curve showed that the average operating time for the first 5 MAPs was 140 minutes, with the operating times decreasing over time and leveling off at an average of 81 minutes within the first 100 MAPs studied (τ=0.093; p=0.17, Figure 6).

Figure 4. Positioning of target instrument set (A) and remaining working cannula (B) after target instrument set removal.

DISCUSSION

In this comparative study of 200 cases, 100 underwent a DAA and the remaining 100 underwent anterior path (MAP). Both cohorts had a mean age of 68 years, although the DAA group had a higher proportion of female patients. BMI was similar in both groups. The study found that, on average, procedures performed with the DAA technique were completed more quickly than those performed with the MAP technique. In addition, there were only slight differences in the surgical placement of the prosthetic cup between the two methods. In addition, hemoglobin levels decreased at a similar rate after surgery in both cohorts. Notably, there were no reported complications in the overall patient

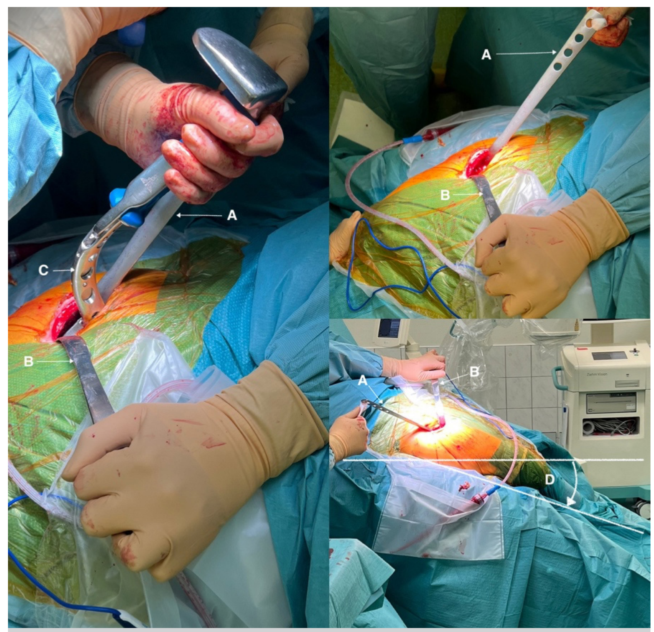

Figure 5. A femoral elevator (A) is placed laterally under the greater trochanter, and another hook (B) is placed on the medial calcar for better exposure. The proximal femur is now exposed by adduction and external rotation as the table legs are lowered.

Figure 6. Learning curve analysis of AnteriorPath surgeries over the course of 100 procedures (X-axis: duration of surgery; Y-axis: date of surgery).

population, although some additional surgical procedures were required in selected DAA cases (screw fixation of the cup, stem cementation). The study also highlighted a learning curve associated with the MAP technique, with notable improvements in operative time observed following the initial procedures.

Operative Time and Complication

The shorter operative times associated with the DAA observed in this study are consistent with findings from the literature suggesting that the DAA may be associated with efficient surgical technique and potentially faster recovery; although, the difference in operative times requires further investigation to establish clinical significance (10,13). Both MAP and DAA demonstrated similar short-term outcomes and postoperative hemoglobin decline. This finding is consistent with studies reporting no difference in blood loss or transfusion rates between another Microport percutaneously assisted MI-THA approach (SuperPath) and DAA, as reported in studies (12,17). Regarding the very low transfusion rate of 0.5% (1 in 200 patients) found in our study, a clear reduction in the need for transfusion can be seen when comparing the results of the present study with the transfusion rate of Penenberg et al. (3). They published a comparable study of 226 patients who underwent the PATH technique, also developed by Microport, showing a transfusion rate of 10% (3). The need for additional screws and cementation in the DAA group, as seen in this study, may indicate a need for increased intraoperative stability, which has also been noted in the literature (3,11).

Implant Positioning

We found no significant difference in cup orientation between the two groups. However, the clinical implications of the observed differences in cup tilt and anteversion angles between the two approaches are not entirely clear and warrant further investigation to determine their significance on patient outcomes (12,13). The recommendation for acetabular cup placement in THA is a general guideline aimed at achieving optimal alignment and stability. Individual patient characteristics and pre-existing conditions may require personalized adjustments to these guidelines. An example of this is flat back syndrome, which can affect pelvic tilt and may require a different cup orientation.

Dennis et al. (17) indicated that customizing the position of the cup based on spinopelvic (SP) mobility patterns can result in a significant reduction in the incidence of prosthetic impingement. The incidence rate was found to be as low as 9%, in contrast to the range of 18-61% observed with non-individualized positions. However, cup placement had no effect on bone impingement, which occurred in approximately one-third of patients regardless of cup orientation. In addition, the study highlighted specific risk factors associated with impingement during flexion and extension, including age, lumbar flexion, pelvic tilt, pelvic rotation, and functional femoral stem anteversion. These findings strongly suggested that performing a preoperative SP analysis to determine an individualized cup orientation can effectively reduce the occurrence of prosthetic impingement. However, it is important to remember that bone impingement remains an important consideration in THA planning (18). Another study by Danaei and McPhee (18) presented an optimization approach based on a model of acetabular cup orientation in THA. This approach uses patient-specific motion capture data to calculate hip contact forces and the relative orientation of the femur and pelvis through a musculoskeletal model. Two measures, angular impingement distance and angular edge loading distance, were defined to quantify the risk of impingement and edge loading at different cup orientations. The optimization framework used three criteria to determine the optimal cup orientation, thereby addressing the trade-off between impingement and edge-loading risks. This approach is particularly noteworthy because it eliminates the need for force plate measurements by estimating ground reaction forces and moments, making it more practical and cost-effective. The results highlight the importance of patient-specific factors, such as pelvic tilt, in determining optimal cup alignment, particularly affecting cup anteversion values. The results suggest that deviations from the Lewinnek safe zone may be necessary to achieve individually optimal results. The low computational complexity of the method made possible by the use of analytical formulas, makes it suitable for real-time application in both preoperative and intraoperative settings (19,20). In conclusion, both MAP and DAA are effective surgical approaches to MI-THA, each with different operative timeframes and technical considerations. The choice of approach should take into account patient-specific factors, surgeon experience, and the nuanced differences highlighted in the literature, such as (11-13,17).

Skin Incision

Skin incisions aligned with the cleavage lines (also known as Langer lines) are generally considered superior due to reduced scarring, faster healing, and improved cosmetic results, such as with the bikini incision. These lines correspond to the natural orientation of collagen fibers in the dermis, and incisions made along them tend to be less disruptive. Studies support that following these lines can minimize the tension on the wound, resulting in a more aesthetically pleasing and functional scar (15,21-23).

Patient Reported Outcome Measures (PROM)

The absence of PROMs in the current investigation can be attributed to the limited duration of the study, which only provided short-term results. A comprehensive examination and meta-analysis (published in 2019 in the esteemed Journal of Arthroplasty) meticulously compared the PROMs associated with DAA and other conventional THA techniques, as well as minimally invasive THA (MI-THA) procedures. The authors of this study discovered that there were no discernible disparities in PROMs, encompassing pain levels, functional capabilities, and postoperative complications, among the aforementioned surgical approaches. Nevertheless, it is imperative to acknowledge that the authors expressed some reservations, highlighting that the studies encompassed within their systematic review exhibited a level of quality that ranged from substandard to moderate, thereby necessitating the inclusion of further high-quality investigations to substantiate their conclusions (24).

This study, along with the Penenberg et al. (3) PATH study and the Ramadanov et al. (11) SuperPATH study, collectively serves to further the understanding and knowledge in the field of minimally invasive (MI-THA). These studies highlight that different surgical techniques can effectively achieve comparable goals of joint stability and accurate placement of hip components. Each technique has unique considerations and potential advantages that enhance the adaptability and overall success of MI-THA. These valuable contributions play a critical role in expanding the range of surgical options available to orthopaedic surgeons, ultimately leading to improved patient outcomes in hip replacement surgery (3,4,11-13).

Potential Limitations

Limitations include the retrospective design, potential selection bias, and reliance on short-term follow-up data that may not fully capture long-term outcomes or rare complications. In addition, the comparative analysis of DAA and MAP approaches was limited to the experience of a single institution, which may affect the generalizability of the findings. It is recommended that future studies validate these preliminary results and investigate the impact of individualised cup orientation on patient-specific outcomes in MI-THA.

CONCLUSION

Anterior path has been demonstrated to provide reliable results, despite the presence of a steep learning curve. The employment of a working cannula has been shown to enhance the surgeon's perspective during the preparation of the acetabulum. In relation to skin incision, the bikini line incision, which is regarded as advantageous due to its alignment with the cleavage lines, is recognized by patients as beneficial.

Ethics

Ethics Committee Approval: The Mann-Kendall trend test was used because it does not depend on the normal distribution of the data and is suitable for time series data. The research was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the institutional review board of the University Duisburg-Essen (23-11274-BO).

Informed Consent: All authors have given a written declaration of consent for publication of the data obtained in this study.

Footnotes

Author Contributions

Concept - H.H., P.G.; Design - H.H.; Supervision - S.F., P.G.; Data Collection or Processing - A.G., J.G.; Analysis or Interpretation - A.G., M.M.; Literature Search - P.G., R.N.; Critical Review - H.H., M.D.; Writing - P.G., S.F., R.N.

Conflict of Interest: No conflict of interest was declared by the authors.

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